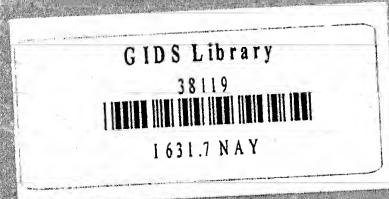


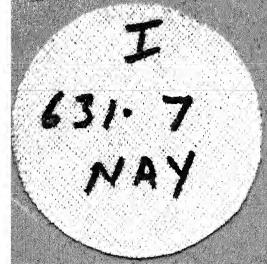
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Inequity in Distribution of Water Resources: A Study of Groundwater Irrigation across States in India

Sanatan Nayak



February 2008



**Giri Institute of Development Studies,
Sector O, Aliganj Extension Scheme,
Lucknow-226024**

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Inequity in Distribution of Water Resources: A Study of Groundwater Irrigation across States in India

Sanatan Nayak¹

Abstract

The paper examines the extent of groundwater depletion and inequity in the accessibility of minor surface and groundwater irrigation by different farm sizes across states in India. These aspects are analysed by using secondary data from agricultural census and minor irrigation census. Inequity is measured with the help of Gini-Coefficient and Theil Index. It is observed that due to proliferation of Water Extraction Devices (WED) and individual ownership of WED, serious groundwater depletion took place. Nearly, 44 percent of the total villages were under semi-critical and critical zones at all India level by 2000-01. It is also found that nearly 12 percent of the total useable schemes became defunct and 9 percent of the net irrigated area is lost at all India level mostly by groundwater depletion due to insufficient power supply, mechanical failure and other reasons. The results of Gini-Coefficient and Theil index confirm that the intensity of inequity in the distribution of accessibility to groundwater irrigation and minor surface over the area under of different operational holdings has increased from 1990-91 to 2000-01. In addition, survey in two villages confirms disproportionate sharing of water favour mostly to the large and medium farmers belonging to general and OBC category.

¹ Fellow, Giri Institute of Development Studies, Sector 'O', Aliganj, Lucknow-24, E.mail: sanatan5@yahoo.com. This is the revised version of the paper presented earlier in the internal seminar of the Institute and at the International Conference of Environmental Economics at New Delhi in December, 2006. The comments made by the participants in the seminar and conference are gratefully acknowledged. My special thanks are to Prof. A. K. Singh, Prof. D. M. Diwakar and other participating members for their suggestions and encouragement.

I. Background

The most important development of irrigation sector during the post-independence period especially after 70's in India is the rapid growth of groundwater irrigation. The proportion of area under canal and tank irrigation to net irrigated area has been declining over time on the one hand, whereas the proportion of irrigated area under tube well alone to the net irrigated area has increased substantially on the other hand during 1970-71 to 2003-04. The area under tube well irrigation has increased from 44.61 lakhs hectares (12 percent to the net irrigated area) in 1970-71 to 241 lakh hectares (43 percent to net irrigated area) in 2003-04, whereas the area under other wells has increased from 74 lakh hectares in 1970-71 to 110 lakh hectares in 2003-04 (Ministry of Agriculture, 2004-05). The share of both tube well and other wells to the net irrigated area has increased from 37 percent in 1970-71 to nearly 64 percent in 2003-04 at all India level. As a result, irrigation along with chemical fertilizer, HYV seeds and modern technology has contributed to increase the production of foodgrains from 99.50 million tonnes in 1970-71 to 198.36 million tonnes in 2004-05, as well as the productivity of foodgrains has also increased from 872 kg/hectare in 1970-71 to 1731 kg/hectare in 2004-05 at all India level (Reserve Bank of India, 2005-06).

Various factors have contributed to the development of groundwater irrigation in India during post-green revolution period. First, productivity per unit of water tapped is much higher in case of groundwater compared to surface irrigation because (a) groundwater irrigation involves much less waste by way of conveyance, (b) Water Extraction Devices (WED) are predominantly owned and managed by farmers and water is used timely and adequately (Vaidyanathan, 1996; Shah, 1993). Second, the development and availability of electricity and credit at subsidised rate has helped the farmers to increase the area under groundwater irrigation significantly (Shah, 1993; Vaidyanathan, 1996). Third, improvement of technology of drilling and lifting of water have made it possible to tap dipper aquifer, pump larger volumes of water and lower the cost per unit of water pumped (Vaidyanathan, 1996). Fourth, the introduction of free boring schemes also helped the farmers to adopt groundwater irrigation at a rapid rate in some of the states, viz., Uttar Pradesh (Pant, 2004). Fifth, the development of water markets also helped the owner of WED including small and marginal farmers to invest in tube wells through the prospect of profitable water sales (Narayananamoorthy, 1993; Saleth, 1996; Shah, 1993). Finally, development of positive externality through the use of conjunctive irrigation in many of the states for ameliorating waterlogging/ flood helped exploration of groundwater irrigation through vertical drainage system (Mukherji, 2007).

Several studies have thrown light on different aspects of the groundwater development. The pioneering works of Tushar Shah describe the development of groundwater markets in India under the Neo-Classical economic framework (Shah, 1991, 1993; Shah and Ballabh, 1997; Shah and Raju, 1988). Shah was instrumental in drawing the attention to emergence of market forces and the exploitation of groundwater. These studies described the nature of groundwater markets and its types, functioning, extent and impact etc. Simultaneously, another set of work on importance of groundwater irrigation notably by B.D. Dhawan (1982; 1988; 1993; 1995) on large and lumpy investment necessarily to assess the deep groundwater requirement with active state intervention. Some of the studies revealed the

importance of economics of information on groundwater (Aggarwal, 2000). This approach examined water share contracts as a solution to double sided incentive problem, i.e., providing a seller incentive for timely supply of water and a buyer incentive for appropriate labour effort. It highlights the importance of risk and information in agrarian markets. Some of the pioneering work deals with the political economy approach of irrigation vis-à-vis agricultural development (Bharadwaj, 1990; Wood, 1995). The central idea of political economy approach is that the exercise of power is the main determinant of conditions of access to water. There are large number of studies that deal with the differential functions of water markets under different ecological and social context. Dubash (2000) point out that groundwater operates in an ecological and social embedded exchange system. Under the ecological context, there has been numerous consequences such as depletion due to heavy demand, increase in cost of extraction and developing inequity in sharing groundwater as highlighted by different scholars.

There has been over-extraction of groundwater leading to depletion in several areas. It leads to alarming depletion of groundwater aquifers (Dubash, 2002; Iyer, 2003). The National Water Policy, 1987 laid down the principle that extraction should not exceed the annual rate of recharge, but this has not been enforced properly. In addition, the NWP 1987 talked about the conjunctive use of surface and groundwater, but this too has not been translated into action. The costs of groundwater irrigation due to over exploitation are being increasing alarmingly (Reddy, 2005). The physical shortage of water has been growing on the one hand and costs of extraction of water have been increasing on the other hand. Though groundwater is traded extensively for agricultural purposes, no price is paid for the use of water lying in the aquifers.

There has been no great gain in equity or social justice in the extraction of groundwater (Dubash, 2002). In fact inequities appear to have been accentuated in many ways; as a result free riding externalities occurred and large farmers got higher share of groundwater and it is not treated as a common pool resource (Dubash, 2002; Pant, 2005; Reddy, 2005). Attempts by the government agencies to regulate water use by different users by means of state law have often not succeeded in decreasing conflicts and may in fact have led to uncertainty about the water rights for the traditional water holders (Raju, 2005). The elites are more likely to negotiate better water rights for themselves than those of the less powerful. In other words, water tends to flow away from the poor and powerless toward those better endowed politically and economically. This is because the elites control the decision making processes that legitimize the rules for allocation and distribution of water.

Objectives

Considering the approach of ecological and social embedded exchange system a recent phenomenon, the study focus on the following issues. First, to assess the extent of groundwater depletion and the factors held responsible for its consequences across the states in India. Second, to estimate the level of inequity in accessing various types of groundwater and minor surface irrigation sources across the states in India. Third, examining the extent of inequity in the functioning of markets in groundwater extraction in an ecological and social embedded exchange system by surveying two villages in Uttar Pradesh.

(4)

Methodological Issues

The use/extraction/depletion of groundwater has been examined at all India level by using three sets of data, viz., volumetric data on groundwater, irrigated area statistics, data on water table depletion (Dhawan, 1995). The data on volumetric use of groundwater relate to annual replenishable water and total discharged water. Based on Groundwater Estimation Committee (1984 and 1997), the extent of use of groundwater has been estimated and area (block/tahesil) under white, grey, dark and over exploited has been identified (CGWB, 1995; 2006)². However, the data on volumetric methods (CGWB, 1995 and 2006) have its own limitation as it contains no information on actual changes of groundwater level (Janakarajan, et al., 2006). The extent of groundwater use can be verified by looking into various types of data on groundwater irrigated area. There are numerous sources portraying that the area under groundwater irrigation has been increasing over the years and is the most important form of irrigation. Moreover, this method also does not contain the actual changes in the groundwater level. The data on water table measurement is a regular phenomenon in recent years for measuring the level of groundwater depletion/ over exploitation. The Groundwater Department of various State Government measures the level of groundwater at various hydrologic points in various seasons and the macro level data are compiled by Ministry of Water Resources, Government of India. These data are published in Minor Irrigation Census Report. The Minor Irrigation Census provides very comprehensive data on water table at the village level for most of the States and Union Territories. Here, we have used the data on groundwater table at village level in different states by using 2nd and 3rd Minor Irrigation Census.³ Many studies on the impact of groundwater depletion and inequity in the accessibility have been studied at micro level earlier. However, this study portrays the macro level picture of groundwater depletion and inequity in land distribution led inequity in accessibility of groundwater and minor surface irrigation by using different sets of data published by Ministry of Water Resources. Moreover, it is also supplemented by surveying two villages in Uttar Pradesh for identifying the inequity in the functioning of water markets. The extent of groundwater depletion, level of inequity in possessing land and various types of minor surface and groundwater irrigation for different classes are analysed by taking data from various secondary sources, viz., Minor Irrigation Census, Agriculture Census, and Statistical Abstract in India. The data on number of operational holdings and area under operations of all categories of farm size are taken from Agricultural Census, Ministry of Agriculture, 1990-91 and 2000-01. Whereas the number of various minor and groundwater irrigation sources⁴ among all operation holdings are taken from 2nd and 3rd Minor Irrigation Census, Ministry of Water Resources for 1990-91 and 2000-01 respectively.

² In 1984, Groundwater Estimation Committee (GEC) suggested the methodology for estimation of dynamic groundwater resources. Based on this recommendation, national level report has been brought out in 1995 by compiling the data of all the states and UTs with the base year varied from 1991-93. Similarly, second GEC was formulated in 1997 and the working group brought its national level report in 2006 with the base year from 1998-2004. Accordingly, where an area/ block/district is called white (safe)/ grey (semi-critical)/dark (critical)/over exploited, where rate groundwater use is less than 70 percent, 70 percent to 90 percent, 90 percent to 100 percent and above 100 percent respectively.

³ The First Census of Minor irrigation Scheme was conducted under the centrally sponsored plan "Rationalization of Minor Irrigation Statistics" of Ministry of Water Resources in all the States and UTs with reference year 1986-87 and all India Report was published in 1993. Second Census of Minor Irrigation scheme was conducted with reference year 1993-94 in all the states and UTs and the report was published in 2001. The Third Minor Irrigation Census was conducted with reference year 2000-01 and the report was submitted in 2005. The methodology and coverage of 3rd Census is same as of 2nd census except slight modification in collection of information.

Though total sample sizes are different in these two sources, yet the data on the number and area under different operational holding and the number of minor and groundwater irrigation sources are directly comparable in 1990-91 and 2000-01.⁵ We have estimated the level of inequity based on the data proportion to the total number not the absolute figure.⁶ Considering the scope of the data and its richness, we have incorporated the 2nd and 3rd Minor Irrigation Census data and compared with the Agricultural Census data in 1990-91 and 2000-01 respectively for estimating the inequity in accessibility of groundwater. The level of groundwater depletion, inequity in accessibility of water through various types is estimated for twenty major states.

The level of inequality in the accessibility of minor and groundwater irrigation sources among various farm sizes across the states has been estimated by using the popular Gini Co-efficient (World Development Report, 2006)⁷ and Theil Index (Sampath, 1992; Selvarajan et al, 2003). For our purposes, given the grouped data at the state level, Theil's variant of the information theoretic measure can be defined as:

$$T(X:Y) = \sum_i X_i \log (X_i/Y_i)$$

Where,

X_i = the total number households in the i th farm size class as a proportion of the total in the country as a whole;

Y_i = the irrigation schemes as proportion to total in the country as a whole.

Finally, the inequity in the functioning of water markets and its impact of different classes has been assessed in a varied ecological and social embedded exchange system of two villages in Uttar Pradesh. Two villages have been selected based on the criteria of differences in water resource depletion. One village is selected from Fatehpur district of Central Region in Uttar Pradesh, where water table normally goes beyond 20 meters (critical region) in the Rabi season. Whereas, another village is selected from Azamgarh district in Eastern region of the state, where water table normally stay within 15 meters (semi-critical region) in the Rabi season. Though the total sample size is quite small (restricted to 32 respondents) in the two villages, yet it provides some of the important aspects covering all social category and all types of farm sizes.

This study consists of five sections. Section I deals with background, literature review along with objective and methodology of this study. While, Section II highlights the extent of groundwater depletion across states along with the extent of defunct and under utilised groundwater schemes and factors determining the under utilization of various schemes. Section III estimates the inequity in the accessibility of groundwater and surface minor schemes with the number and area under different operation holdings. Whereas, Section IV spell out the extent of inequity in availing the groundwater irrigation among various farm sizes in two villages of Uttar Pradesh. Last section deals with conclusions and policy implications of the study.

⁴ There are five minor surface and groundwater irrigation sources, viz., Deep well, Dug Well, Shallow Tube well, Surface flow and Surface lift as mentioned in the 2nd and 3rd Minor Irrigation Census published in 1990-91 and 2000-01 respectively.

⁵ The sample size of total number of operation holding in 2000-01 was 1208 lakhs, whereas the sample size of total number of minor surface and groundwater irrigation sources are 186 lakhs in 2000-01.

⁶ Various types of operation holdings in Agricultural Census and Minor Irrigation Census are different. There are five categories of operation holdings in Agricultural Census, while the operational holdings are four categories in Minor Irrigation Census. In this case, we have clubbed both semi-medium and medium category of operation holding in to medium operation holding for comparison purposes.

II. Extent of Groundwater Depletion

The use of groundwater is called over exploited, when groundwater withdrawals exceeds the inflow/recharge into a given groundwater reservoir or aquifer (Dhawan, 1995). There are number of symptoms such as, reduction in irrigated area per well, reduction in discharge of water from pumps and bore wells, increase in well-deepening by farmers, premature drying up of shallow wells for groundwater depletion. Based on first type of definition mentioned in the methodology section, though the CGWB have identified the overall stage of groundwater development in the country is 58 percent, indicative of a comfortable situation at the aggregate level, but it portrays high degree of variability in availability and development throughout the country (CGWB, 2006). For example, the extraction of groundwater has crossed more than 100 percent in some of the states, viz., Delhi (170 percent), Haryana (109 percent), Punjab (145 percent) and Rajasthan (125 percent) (CGWB, 2006). The areas under critical and semi-critical areas are significant in some of the states, viz., Gujarat (76 percent), Tamil Nadu (85 percent), Karnataka (70 percent), Uttar Pradesh (70 percent) and Uttarakhand (66 percent). The extent of extraction has increased significantly over the years as the number of wells and tubewells has gone up substantially. Moreover, the demand for domestic and industrial uses is projected to rise to 29 BCM from the current level of 18 BCM by 2025 (Planning Commission, 2007). Under these circumstances, this definition does not provide the comparable time series data on proliferation of semi-critical, critical and over exploited blocks/districts (depth wise). This deficiency has been covered by using the depletion of groundwater table data (under the third definition) over a period of time across states by using the data produced by Minor Irrigation Census. Though there has not been standard definition of measuring the depth of depletion in terms of its seriousness, yet some of the states have used their own definition.⁸

It is found that the irrigation potential created has exceeded the ultimate potential, showing that mining of groundwater is taking place through the exploitation beyond the dynamic resources in many states (Planning Commission, 2007). Here, we have attempted to identify the seriousness of the groundwater depletion by using Minor Irrigation census data. The comparison between Second and Third Minor Irrigation Census showed that the number of villages under semi-critical and critical zones had increased over the decade (Table 1). Second Minor Irrigation Census portrayed that nearly 1.15 lakh villages, that is 21 percent of total 5.45 lakh surveyed villages were under critical zone. Moreover, nearly 0.96 lakh villages, which were 18 percent of the total villages, were under semi-critical zone. Whereas, the Third Minor Irrigation Census indicated that nearly 1.62 lakh villages, or 25 percent of the total 6.37 lakhs surveyed villages in different states, were under critical condition. The Census also indicates that another 1.20 lakh villages, nearly 20 percent were under semi-critical conditions. The water table had gone down below 25m of the ground level for nearly 15 percent of the total surveyed villages. The problem of water depletion is very serious in some of the states, viz., Karnataka, Gujarat, Haryana, Rajasthan, Pondicherry, Andhra Pradesh, where more than 60 percent of the total surveyed villages have water table below 15 meters. In Karnataka, nearly 71.65 percent and 2.65 percent of the total surveyed villages are under critical and semi-critical zones (Table 1). Gujarat, Rajasthan and Haryana are also severely affected states under water depletion, where 71.30 percent, 69 percent and 62 percent of the villages were under critical zone. The water table is under critical zones in 2/3 villages of Rajasthan due to scanty rainfall and geographical location of the state and proliferation of tubewells and deep wells etc. has created groundwater depletion in other states.

Table 1: Percent of Villages under Groundwater Depletion across States in India

States	Second Minor Irrigation Census, 1990-91			Third Minor Irrigation Census, 2000-01		
	Up to 10 meters	10-15 meters	More than 15 meters	Up to 10 meters	10-15 meters	More than 15 meters
Andhra Pradesh	37.60	19.00	39.08	23.79	20.84	55.38
Arunachal Pradesh	NA	NA	NA	68.54	6.41	25.05
Assam	99.99	0.01	0.00	84.45	8.00	7.54
Bihar	43.99	27.39	24.38	74.19	5.32	20.49
Gujarat	NA	NA	NA	8.33	20.06	71.61
Haryana	NA	NA	NA	13.24	24.72	62.04
Himachal Pradesh	74.00	3.43	21.89	52.34	8.45	39.21
J & K	NA	NA	NA	61.20	8.15	30.65
Jharkhand	29.41	7.35	54.41	36.10	57.78	6.12
Karnataka	NA	NA	NA	25.79	2.56	71.65
Kerala	NA	NA	NA	79.15	18.40	2.44
Madhya Pradesh	68.97	23.82	6.59	57.18	29.81	13.01
Maharashtra	NA	NA	NA	36.45	31.39	32.16
Orissa	77.49	15.11	5.80	83.79	13.13	3.08
Punjab	39.55	60.45	0.00	37.77	38.62	23.61
Rajasthan	24.09	23.27	45.69	6.73	23.43	69.83
Sikkim	98.38	0.00	1.62	43.78	8.37	47.85
Tamil Nadu	NA	NA	NA	38.07	26.07	35.85
Uttar Pradesh	76.64	13.99	8.29	69.71	14.91	15.38
Uttaranchal	NA	NA	NA	87.67	1.04	11.29
West Bengal	66.78	21.20	12.02	80.10	14.46	5.43
All India	58.69	17.68	21.14	55.78	18.82	25.40

Source: Estimated from Second and Third Minor Irrigation Censuses, Ministry of Water Resources, Government of India.

Note: NA means Not Available

The major cause of over-exploitation is the rising demand for groundwater for agriculture. Moreover, decision on changing cropping pattern and cropping intensity towards more remunerative and water consuming crops (which are independent of the groundwater availability) are also cause of groundwater depletion (Planning Commission, 2007). The severity of groundwater depletion may be caused due to indiscriminate extraction of water resources through proliferation of tubewell, deep well etc. with cheap/subsidised or even free power, which constitute main component of groundwater irrigation. The Planning Commission Report clearly revealed that

⁷ The Gini-Coefficient takes on values between 0 and 1, as 0 is interpreted as perfect equality, while 1 implies perfect inequality. It shows that higher the value move towards one implies higher degree of inequality and vice-versa.

⁸ Report on Water Sector Restructuring project in UP defined, "Water table lying below the ground up to 5m, 5m to 10m, 10m to 15m and more than 15m are known as waterlogged and its sub-heads, safe zone, semi-critical and critical zone respectively (Rai, 2003).

the state with higher per capita consumption of power in agriculture vis-à-vis lower agriculture tariff (higher subsidy or total free) has more semi-critical and critical blocks in the recent years. This aspect has been clearly reflected in Gujarat, Haryana, Karnataka, Punjab, Andhra Pradesh, and Tamil Nadu (Planning Commission, 2007). Similar observation has been obtained in Andhra Pradesh that the areas of groundwater depletion (both semi-critical and critical zone) takes place due to increase in number of bore well or open well on the one hand and without improving proper replenishing mechanism for recharging the water table (Reddy, 2005).

The consequences of over-exploitation of groundwater are felt in terms of increase in pumping depths, reduction in well/tubewells yield, deterioration in the quality of groundwater (contaminated by arsenic and fluoride), saline ingress in coastal areas (Planning Commission, 2007). More importantly, over-exploitation of groundwater resources makes defunct/under-utilization of the existing minor and groundwater schemes. There are four underlying reasons identified for the defunct/under utilisation of the existing minor and groundwater schemes, viz., less water recharge or depletion of water table, inadequate power supply, mechanical failure and other reasons (Ministry of Water Resources, 2005). The Third Minor Irrigation Census estimates that nearly 22.18 lakh minor surface and groundwater schemes, which are nearly 12 percent of the total useable schemes, became defunct due to above mentioned reasons by the reference year 2000-01 (Table 2). Out of the total defunct schemes, only groundwater irrigation schemes constitute nearly 20.72 lakhs, which is 11.65 percent of the total useable groundwater irrigation schemes. Some of the states, viz., Gujarat, Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Rajasthan, Orissa, and Tamil Nadu are worst affected, where more than 20 percent of the total minor and groundwater schemes became defunct. As a result of defunct of the groundwater and minor surface irrigation schemes, nearly 49.37 lakh hectares (9 percent of the net irrigated area) of irrigated area are lost at all India level by the same year. Some of the states, viz., Andhra Pradesh, Chhattisgarh, Gujarat, Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Tamil Nadu lost more than 10 percent of their respective net irrigated area due to defunct of these schemes by the same year.

Table 2: State wise Share of Defunct Minor Irrigation Schemes and Loss of Command Area to Net Irrigated Area in 2000-01 (in Percent)

States	Defunct Minor surface and Groundwater irrigation schemes to total Used Sources	Defunct Groundwater schemes to total Used Sources	Defunct Minor irrigation schemes to Used minor Sources	Loss of Groundwater Command area to NIA	Loss of Minor Surface Command area to NIA	Loss of both Minor Surface and Groundwater Command area to NIA
Andhra Pradesh	15.49	14.20	92.97	6.16	6.87	13.03
Arunachal Pradesh	33.38	100.00	33.32	0.36	34.15	34.51
Assam	7.17	6.05	33.71	12.69	25.76	38.45
Bihar	10.42	9.98	71.95	8.53	4.02	12.56
Chhattisgarh	26.01	20.78	66.77	5.64	4.95	10.58
Goa	2.52	1.88	3.20	0.55	1.15	1.70
Gujarat	22.85	22.41	89.36	18.22	1.74	19.96
Haryana	3.56	3.55	5.93	1.23	0.01	1.24
Himachal Pradesh	4.26	1.71	5.93	0.31	1.80	2.11
J & K	7.10	2.62	12.20	0.36	3.02	3.39
Jharkhand	6.51	5.37	17.51	NA	NA	NA
Karnataka	4.40	3.90	11.40	1.84	3.17	5.01
Kerala	1.91	1.29	8.28	0.34	3.02	3.37
Madhya Pradesh	16.82	18.12	7.92	12.63	1.41	14.04
Maharashtra	11.11	11.29	8.79	11.38	1.24	12.63
Manipur	0.00	NA	0.00	0.00	0.00	0.00
Meghalaya	3.43	43.33	3.23	0.27	15.99	16.26
Mizoram	14.18	NA	14.18	0.00	15.36	15.36
Nagaland	7.54	56.79	6.83	0.49	5.91	6.40
Orissa	26.29	25.30	40.93	5.63	6.60	12.23
Punjab	0.37	0.37	2.79	0.37	0.01	0.38
Rajasthan	26.36	26.29	59.38	13.44	1.08	14.53
Sikkim	55.83	NA	55.83	0.00	27.56	27.56
Tamil Nadu	21.99	21.70	41.32	13.69	3.58	17.27
Tripura	11.49	9.40	14.17	2.09	9.05	11.14
Uttar Pradesh	1.63	1.57	19.12	1.98	0.07	2.05
Uttaranchal	12.20	1.42	84.29	NA	NA	NA
West Bengal	5.53	5.10	7.31	3.52	3.53	7.06
All India	11.91	11.66	17.24	6.74	2.30	9.03

Sources: Estimated from Third Minor Irrigation Census and Statistical Abstract, Government of India.

It is revealed that depletion of groundwater table without sufficient replenishment mechanism is the major factor among various causes described above for the defunct/under utilisation of the huge groundwater and minor surface irrigation

tubewell, schemes at the all India level. The Third Minor Irrigation Census portrays that 51.47 lakh schemes (which is 43 percent of the total defunct schemes) became defunct/under-utilised due to depletion of water table or inadequate replenishment mechanism at all India level (Ministry of Water Resources, 2005). This has been substantiated that the life span of tubewell is about 10 years but due to depletion of groundwater, the life span has declined to 7 to 8 years in recent years (Times of India, 2006, P.2).. Most importantly, some of the states, viz., Andhra Pradesh, Jharkhand, Gujarat, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu, where more than 60 percent of the total under utilised minor and groundwater irrigation schemes are due to depletion of water table. Secondly, only 11.18 percent and 6.63 percent of the total defunct schemes are due to inadequate power supply and mechanical failure at the all India level. Thus, these two reasons are not important factors for the defunct/under utilization of the existing schemes. Punjab and Karnataka is worst affected by shortage of power supply, where as Bihar and Uttar Pradesh are severely affected by mechanical failure. Other reason may be naturally crossing the life span of the tube wells, official over estimation of existing schemes or non-availability of physical presence of the schemes (with due official records) for the defunct/under utilization of the minor irrigation schemes.

III. Inequity in the Accessibility of Groundwater

Quantitative assessment of inequality in irrigation is considered extremely important for strengthening irrigation policy to achieve desired development objectives (Sampath, 1992; Selvarajan et al, 2003). The measurement of inequality in irrigation water distribution implies the distribution of both major and medium surface irrigation as well as minor surface and groundwater irrigation. The measurement of inequity in the accessibility of various sources of irrigation has been extensively studied during 80's in India (Sampath, 1990; 1992). The studies have observed that the propagation and diffusion of irrigation sources among the agricultural households seems to be in favour of large farmers. However, the data on groundwater irrigated area corresponding to different farm size is sadly not available at different states vis-à-vis national level in recent years. Therefore, here attempt is made to assess the inequality in accessibility of different types of minor and groundwater irrigation among different size holding for different states in India. As distribution of water is very much attached with the corresponding distribution of landholding size among different class and ownership, it is important to examine first the inequality of ownership and land holding size.

The present study confirms the persistence of substantial inequality in the number and distribution of area under various size holdings in different states in India. Marginal size class (who holds less than one hectare of land), which constitutes nearly 63 percent of the total number of operational holding occupying only 19 percent of the total operational area in India in 2000-01. Small farmers constitute nearly 19 percent of the total number of operational holdings but they occupy nearly 20 percent of the total area of land cultivated. More importantly, medium (both semi-medium and medium farmers) farmers constitute nearly 17 percent of the total number of operational holdings and they possess a lion share of 48 percent of the total area operated at all India level. Finally, large farmers constitute only 1

percent of the total number and they hold nearly 13 percent of the total land. Though both Gini-coefficient and Theil index have declined marginally from 1990-91 to 2000-01, yet the inequality of number and area of operational holding by different size holdings is still substantial at all India level (Table 3). This analysis confirms that the level of inequity has increased over the decades in Haryana. However, level of inequity is lower in the distribution of land among various categories of farmers in Arunachal Pradesh, Bihar, Gujarat, J& K, Maharashtra, Orissa, Punjab, Uttar Pradesh and West Bengal, whereas moderate level is observed in Andhra Pradesh, Assam, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Chhattisgarh, Tamil Nadu, Uttaranchal. The third category of states, where the level of inequity is quite higher are Haryana, Rajasthan, Sikkim. The marginal decline of inequity over the last decade in India is attributable due to increase of area owned by marginal size group (Singh, 2006). The increase in the number of farms and substantial fragmentation may lead to marginal decline of inequity in the distribution of land among various classes.

Table 3: Inequity measure of Number of Operational Holdings and Area among States in India

States	1990-91		2000-01	
	GC	Theil Index	GC	Theil Index
Andhra Pradesh	0.53	0.51	0.49	0.35
Arunachal Pradesh	0.43	0.36	0.43	0.19
Assam	0.53	0.51	0.51	0.37
Bihar	0.50	0.47	0.44	1.07
Gujarat	0.48	0.44	0.45	0.08
Haryana	0.53	0.54	0.57	0.49
Himachal Pradesh	0.52	0.49	0.49	0.45
Jammu & Kashmir	0.44	0.36	0.39	0.74
Karnataka	0.51	0.49	0.50	0.18
Kerala	0.46	0.48	0.40	1.43
Madhya Pradesh	0.55	0.59	0.51	0.21
Maharashtra	0.48	0.43	0.47	0.13
Orissa	0.45	0.35	0.43	0.16
Punjab	0.49	0.48	0.42	0.21
Rajasthan	0.58	0.69	0.57	0.45
Sikkim	0.57	0.64	0.54	0.34
Tamil Nadu	0.51	0.48	0.49	0.62
Uttar Pradesh	0.48	0.42	0.44	0.69
Uttaranchal	NA	NA	0.44	0.68
West Bengal	0.41	0.32	0.33	0.66
All India	0.58	0.62	0.55	0.51

Source: Estimated from Agricultural Census, 1990-91 and 2000-01, Ministry of Agriculture, Government of India.

Inequity in accessibility of groundwater irrigation schemes by different categories of farmers has been estimated in two ways. Firstly, the number of operational holdings of different categories and their accessibility to the number of different types of minor and groundwater irrigation sources, viz., deep tubewell, shallow

dug well, surface flow and surface lift schemes in different states of India. Secondly, the area of operational holdings of different categories of farmers and their accessibility to the number of different sources of minor and groundwater irrigation in different states of India is also attempted.

The marginal, small, medium and large farmers constitute nearly 63 percent, 19 percent, 18 percent and 1 of the total number of operational holdings and their accessibility to the minor and groundwater irrigation sources is 33 percent, 33 percent, 30 percent and 4 percent respectively at all India level by 2000-01. Moreover, the results of both GC and Theil index confirm the inequity in accessibility to the minor and groundwater irrigation with respect to the number of operational holding in different farm size. The inequality is lower in Gujarat, Karnataka, Kerala, Maharashtra, while it is quite larger in Haryana, Himachal Pradesh, Sikkim, J &K and West Bengal (Table 4).

Table 4: Inequity in Number of Minor and Groundwater Irrigation Sources in India

States	1990-91		2000-01	
	GC	Theil	GC	Theil
Andhra Pradesh	0.20	0.10	0.22	0.12
Arunachal Pradesh	0.17	0.14	0.21	0.17
Assam	0.74	1.85	0.23	0.15
Bihar	0.33	0.25	0.41	0.37
Gujarat	NA	NA	0.07	0.01
Haryana	0.38	0.43	0.66	0.99
Himachal Pradesh	0.81	1.47	0.75	1.19
Jammu & Kashmir	0.25	0.15	0.47	0.45
Karnataka	NA	NA	0.05	0.03
Kerala	0.09	0.04	0.07	0.03
Madhya Pradesh	0.32	0.22	0.30	0.21
Maharashtra	NA	NA	0.04	0.01
Orissa	0.21	0.11	0.18	0.08
Punjab	0.16	0.09	0.15	0.11
Rajasthan	0.23	0.21	0.20	0.19
Sikkim	0.98	NA	0.98	NA
Tamil Nadu	NA	NA	0.23	0.11
Uttar Pradesh	0.31	0.20	0.26	0.14
West Bengal	0.22	0.11	0.70	NA
All India	0.32	0.20	0.28	0.17

Source: Estimated from Second and Third Minor Irrigation Census, Ministry of Water Resources and Agricultural Censuses, Government of India.

Highest level of inequality is found in Himachal Pradesh during the study period covered. The results of both GC and Theil in both Censuses confirm that the level of inequality has declined marginally. Our results confirms the findings of by Pant, who observed that "the accessibility of poor and marginal farmers up to 0.4 hectares to groundwater are the biggest beneficiaries, as about 60 percent of them irrigate their crops using water purchased from the private owners. But, even today the marginal farmers, particularly SCs and STs, the ownership of mechanical water extraction devices and modern agricultural implements remain out of reach. This is despite the high sounding success of the free boring scheme as only about 10 percent SCs own a WED" (Pant, 2005). On the other hand, the level of inequity has increased in Andhra Pradesh, Arunachal Pradesh, Bihar, Haryana, J & k, Punjab and West Bengal, where as it has declined in Uttar Pradesh, Rajasthan, Punjab, Orissa, Madhya Pradesh, Kerala and Himachal Pradesh. Hence, this part of the study highlights that the water markets lead to less egalitarian distribution of gains from groundwater development and inequality of distribution of water among different sections of the farmers.

The inequity in measurement of area under different operational holdings and their accessibility to different sources of minor surface and groundwater irrigation across states provides a direct picture as there has been disproportionate distribution of land among various categories of operational holdings. The operational area under marginal, small, medium and large farmers constitutes 17 percent, 19 percent, 49 percent and 15 percent of the total area under cultivation and they possess nearly 33 percent, 33 percent, 30 percent and 4 percent of the total minor and groundwater irrigation sources at all India level respectively. The results of the GC and Theil confirm that higher degree of equality prevails in Bihar, West Bengal, Uttar Pradesh, Madhya Pradesh, J & K, Haryana, where as higher degree of inequality prevails in Arunachal Pradesh, Himachal Pradesh, Karnataka and Rajasthan (Table 5). This part of the estimation shows that the inequity has increased over the decade at all India level. This kind of result may be different from state to state. For example, there has been development of inequity in Uttar Pradesh at macro level and it corroborate with the findings of micro study (Pant, 2005). On the other hand, though the result of inequality has declined in Andhra Pradesh and it does not corroborate with the result of micro survey (Reddy, 2005). Himachal Pradesh stands at the top of inequality with both kind of analysis.

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Table 5: State wise Inequity in Area under of Operational Holdings with Number of Minor and Groundwater Irrigation Sources in India

States	1990-91		2000-01	
	GC	Theil	GC	Theil
Andhra Pradesh	0.20	0.10	0.22	0.12
Andhra Pradesh	0.37	0.29	0.32	0.24
Arunachal Pradesh	0.48	0.48	0.53	0.60
Assam	0.18	0.53	0.35	0.29
Bihar	0.24	0.17	0.15	0.14
Gujarat	NA	NA	0.48	0.47
Haryana	0.18	0.13	0.25	0.18
Himachal Pradesh	0.60	0.94	0.52	0.76
Jammu & Kashmir	0.17	0.15	0.12	0.17
Karnataka	NA	NA	0.55	0.69
Kerala	0.38	0.43	0.36	0.49
Madhya Pradesh	0.23	0.10	0.26	0.16
Maharashtra	NA	NA	0.41	0.30
Orissa	0.25	0.13	0.27	0.15
Punjab	0.31	0.23	0.28	0.22
Rajasthan	0.43	0.56	0.44	0.54
Sikkim	0.80	NA	0.82	NA
Tamil Nadu	NA	NA	0.31	0.24
Uttar Pradesh	0.20	0.09	0.25	0.16
West Bengal	0.22	0.11	0.15	NA
All India	0.30	0.18	0.34	0.24

Source: Estimated from Second and Third Minor Irrigation Census, Ministry of Water Resources and Agricultural Censuses, Government of India.

The analysis reveals that inequity in distribution of land across the states lead to inequity in distribution of accessibility of minor and ground water irrigation sources. As a consequence, inequity in the extraction of groundwater persists (considering the existence of water market and its consequences)¹ and disproportionate share for the depletion of the natural resources. This has led to indiscriminate exploitation of groundwater by the medium and large farmers. As a consequence, large numbers of marginal and small farmers are debarred to consume water for drinking and agricultural purposes. Therefore, the role of medium and large farmers is larger for the depletion of the natural resources due to the inequity in the accessibility of the minor and groundwater schemes. It is clearly revealed that the minimum water rights are threatened to the marginalized section in the society. Moreover, marginal farmers have to purchase water from large and medium framers at a high rate. When the scarcity of water aggravates further, the owner of WED, use the water first for his own purposes, then selling of water may emerge latter. As a result, the marginal framers are denied for the accessibility of water at the right quantity, at a right time and right quality.

¹ Though the owners of WED (large and medium farmers) sell the water to small and marginal farmers, but they are remunerated at the market rates. But the consequences are not restricted to only use of water rather it goes beyond much more than mere using the water.



IV: Experience of Groundwater Extraction in Uttar Pradesh

Two remote villages (Siyari from Fatehpur district in Central region and Kharianni from Azamgarh in Eastern region of the State) have been selected to assess the differential impacts among different categories of farmers dealing with water market. The major difference between the two villages is that they belong to different ecological embedded system, for example Siyari belongs to the critical groundwater zone whereas Kharianni belongs to the semi critical groundwater zone in the state. However, they have more homogeneity in demographic, social, economic and agrarian structure. Both the villages have all pervasive informal groundwater markets or pump rental market having the basic characteristics of groundwater markets.² In both the villages SCs population is largely concentrated followed by OBCs and General category. Moreover, literacy rate is quite lower (40 percent, 43 percent in Siyari and Kharianni respectively) in both the villages compared to that of average in Uttar Pradesh. Diesel based shallow tubewells are the major sources of WED from groundwater. The concentration of tubewell in Siyari of Fatehpur is higher (one tubewell in 2.93 hectares) than that of Kharianni in Azamgarh (one tubewell in 5.33 hectares).³

Functioning of Water Market

The most important mode of transaction in the water market is mainly of cash payment either an hourly basis immediately or a seasonal basis. The nature of water market is 'more mature' as hypothesized by Shah (1991). While considering the breath of water market, the irrigated area under water markets is 51 percent in Siyari village of Fatehpur, where as it is around 10 percent in Kharianni of Azamgarh. The ratio of water charge (w) to total variable cost (c) in the two villages, it is observed that the value of w/c in Siyari is 1.71, while it is 1.49 in Kharianni. It is reflected here that the groundwater market in both of the villages are far from monopolistic but is more competitive. This is coinciding with the hypothesis of Shah (1993) and Fujita and Hussain (1995) that as the market develops, the value of w/c declines. But the difference in the result of w/c in the two villages may contradict the finding of earlier study. Siyari is the reflection of higher breath with higher w/c to those of Kharianni. Therefore, the prevalence of competitive market with higher price at Siyari is due to the fact of higher ecological degradation (groundwater depletion) rather than entrepreneurs' risk premium.

Equity Implication in the Water Market

Inequity in sharing of water in this two village model has been observed in two ways. Firstly, observing the buyers of water and owners of WED in both villages. Secondly, observing the inequity of water sharing among various land holders in both the villages. Four indicators have been chosen, viz., frequency of irrigation per crop, irrigation charges per hour, total irrigation costs per crop and share of irrigation costs to the total costs to observe the level of inequity in both aspects. Two types of

¹⁰ Basically there are three characteristics in groundwater market of the villages. First, WED are mainly individually owned. Second, Medium and Large farm owners especially forward and OBCs category farmers own the WED. Water buyers are mostly belonging to small and marginal farming community, specifically OBC and SC farmers. Thirdly, the diffusion has taken place to very few cases of small and marginal farmers in the two villages in recent years.

¹¹ The concentration ratio of tubewell is estimated by considering the total area with number of total existing tubewell at the time of survey.

inequities are clearly emerging from the observation due to inequity in accessibility of WED among various land holders. First, quantity of water used by WED owners and buyer per crop is different. Second, per hour expenditure on irrigation for extraction of water by WED owner and buyer is different. First, it is revealed that number of times of irrigation done by WED owners is higher than those of buyers of water (Table 6). Second, the buyers of water for irrigation are marginal and small landholders belonging to Schedule Castes (SCs) and Other Backward Castes (OBCs) in the villages, who pay higher price per hour, which is 1.58 times more than those of WEMs owners. As a result, total costs of groundwater irrigation for both rice and wheat for the water buyers is much higher than that of WEMs owners (Table 6). This is forcing the buyers either to spend more on water purchasing as a single item or to divert their expenditure from other items such as fertilizer demand, applying HYVs etc. It is also reflected that the costs of groundwater extraction is higher in a resource crunch village than in a normal village in terms of per hour charge and total expenditure on groundwater extraction.

Table 6: Inequity of Groundwater sharing among Buyer and WEMs owners

Village	Caste	Rice				Wheat			
		No. of times irrigated per crop	Irrigation Charge per hour in Rs.	Irrigation costs per acre in Rs.	Irrigation/total cost	No. of times irrigated per crop	Irrigation Charge per hour in Rs.	Irrigation costs per acre in Rs.	Irrigation/total costs
Buyers									
Siyari	OBC	4	70	2245	33	4	73	2000	35
Siyari	SC	4	70	1820	28	3	70	1418	36
Kharianni	OBC	3	60	990	14	3	60	1121	34
Kharianni	SC	3	60	1020	18	4	60	1689	37
Average		3	65	1519	23	3	66	1557	36
WEM Owners									
Siyari	Gen	5	45	1079	19	4	45	855	29
Siyari	OBC	4	42	1025	26	3	36	610	18
Siyari	SC	5	42	1575	27	3	42	851	18
Kharianni	OBC	4	41	992	21	4	41	909	25
Kharianni	Gen	5	41	1222	26	4	42	947	28
Average		4	41	1179	24	4	41	834	24

Source: Field Survey

Similar observations has been obtained, with respect to inequity in sharing the groundwater in terms of number of times irrigated, charge of irrigation per hour among various land holders are prevailed in both of the villages. Farmers of marginal and small land holders have to spend more money on hour basis and total expenditure on irrigation than those of medium and large farmers. In addition, the frequency of irrigation of marginal and small land holders is relatively less compared to other farmers (Table 7). Hence, the marginal and small land holders are the first victims of resource crunch arising out of groundwater depletion because they do not have access to resources directly. As a result, the cost of groundwater depletion and quantity of water is disproportionately borne by these farmers.

Table 7: Inequity of Groundwater sharing among various Land Holders

Land Holders	Village	Rice				Wheat			
		Irrigation Charge per hour in Rs.	Irrigation costs (per acre in Rs.)	Irrigation/cost	No. of times Irrigated	Irrigation Charge per hour in Rs.	Irrigation Charge per hour in Rs.	Irrigation costs per acre in Rs.	Irrigation/cost
Marginal	Siyari	3	56	1134	20	3	49	1010	22
	Kharianni	2	60	1028	14	3	56	1372	32
Small	Siyari	5	70	2667	31	4	70	1762	32
	Kharianni	4	40	960	21	NA	NA	NA	NA
Semi-medium	Siyari	5	47	1447	27	4	41	900	29
	Kharianni	4	41	998	21	4	41	843	28
Medium	Siyari	5	48	1185	29	4	53	1093	25
	Kharianni	4	51	923	22	4	48	1051	36
Large	Kharianni	5	41	1325	27	4	41	892	21

Source: Field Survey

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V. Conclusion and Policy Implication

This paper highlights some aspects of inequity in distribution of land and accessibility of WED, which lead to disproportionate use of water among various classes of land holders. In India, substantial inequity persists in the distribution of land among various categories of land holders, which further led to inequity in the accessibility of WED. As a result, individual ownership of WED developed and extraction of groundwater clearly goes in favour of medium and large farmers. This led to indiscriminate extraction of common property resources. Therefore, serious groundwater depletion took place. This further debarred the small and marginal farmers (water buyers) for use of water in domestic and agricultural purposes. This study clearly reveals that small and marginal farmers uses less water than their due share and pays higher prices and which eventually imposes them to spend more on groundwater irrigation. Therefore, the unequal distribution of land use magnifies the internalization of water use rather than common pool resources in India.

The problem occurs due to lack of institutional mechanism that supports the sharing of groundwater equitable among all section of the community, irrespective of their land ownership. One way of minimizing the externalities is to strengthen the resource base that is replenishing groundwater through rain water harvesting. This calls for policy changes towards prioritization of minor surface irrigation in the fragile regions as well as supporting cheaper access to technology. Second, investment on community basis rather than individual basis would be more preferable. Similarly, integration of groundwater development/exploitation with surface water bodies like tanks is a precondition for sustainable water resource management. In addition, economic approaches need to be integrated with institutional arrangements in order to make the policies effective. Community involvement is required to make groundwater a common pool resource in the true sense. Legislation must be

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strengthened to protect the water rights by delinking the land rights. Most importantly, the interest of marginal section can be prevented by providing more WED and irrigation sources.

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